

## Toroidal Cross Capacitors for Measuring the Dielectric Constant of Gases: A Step Towards an Atomic Standard of Pressure

T.J. Buckley, J. Hamelin,<sup>†</sup> and M.R. Moldover  
*Physical and Chemical Properties Division  
National Institute of Standards and Technology  
100 Bureau Drive, Mailstop 8380  
Gaithersburg, MD 20899-8380*

We manufactured two nearly-identical cross capacitors and used them with commercially manufactured instruments to measure the dielectric constants of helium and argon at temperatures in the range 7 °C to 50 °C and at pressures up to 3 MPa. For helium, the resulting value of the molar polarizability  $A = (0.51747 \pm 0.00020) \text{ cm}^3 \text{ mol}^{-1}$  agrees, within experimental error, with the theoretical value  $(0.517253 \pm 0.000010) \text{ cm}^3 \text{ mol}^{-1}$ . This demonstrated that the cross capacitors deformed as predicted when they were compressed by the helium. The predicted performance was confirmed by the good agreement of our argon result  $A = (4.14078 \pm 0.00039) \text{ cm}^3 \text{ mol}^{-1}$  with measurements made in other laboratories. Finally, while evacuated, the temperature dependence of each cross capacitor was close to that predicted from the dimensions and thermal expansion of its sapphire and superinvar components. Taken together, these test results demonstrate that cross capacitors may be used to make very accurate measurements of the dielectric constant of gases.

This work was stimulated by a recent proposal [M.R. Moldover, *J. Research of Natl. Inst. Standards and Tech.* **103**, 167 (1998).] to improve the calculation and the measurement of the dielectric constant of helium to the point where capacitance measurements could be used to calibrate piston gages in the range 0.5 MPa to 5.0 MPa. Progress towards this goal will be discussed.

<sup>†</sup>Present Address: Institut de Recherche sur L'Hydrogène  
Université du Québec à Trois-Rivières  
3351 Blvd. Des Forges  
C.P. 500, Trois-Rivières  
Québec, Canada G9A 5H7